# MIGRATION OF TWO SPECIES OF PIERIDAE (LEPIDOPTERA: PAPILIONOIDEA) IN SOUTHEASTERN AUSTRALIA

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## Abstract

Observations on directional flight and distribution records of *Appias paulina* (Cramer) and *Catopsilia pomona* (Fabricius) from southeastern Australia during late January and mid February 2004 are presented. The appearance of these otherwise tropical/subtropical species in the southern temperate latitudes coincided with observations of a large scale southerly migration recorded by several lepidopterists in southeastern Queensland and northeastern New South Wales, 600-1200 km further NNE, and were almost certainly part of the same mass movement. Climatic variables, particularly rainfall three months earlier following a severe dry period in central Queensland, coupled with above average rainfall in SE Queensland during January 2004, may have provided conditions which triggered the migration.

## Introduction

For many tropical insects in Australia, particularly those associated with seasonally ephemeral resources, migration is an important aspect of the life history strategy (Jones 1987). While migration has been documented for many species of butterflies and moths (Dingle *et al.* 1999), only for a limited number of species in Australia are there sufficient data to interpret overall movement patterns between geographical areas and between seasons (Dingle *et al.* 1999, Greenslade *et al.* 1999). Records of butterfly migration frequently consist of one or a few observations from single localities, often of limited duration, thereby precluding broader understanding of the temporal and spatial scale of the migration. An exception was perhaps the summer of 1973-74, when significant range extensions and/or numbers outside the normal areas of distribution were recorded for many species in southeastern Australia (Quick 1974).

The summer of 2003-04 was remarkable for the large number of species observed migrating simultaneously in southeastern Australia. In southeastern Queensland, 14 species of butterflies (listed subjectively in decreasing order of relative abundance: *Tirumala hamata* (W.S. Macleay), *Catopsilia pomona* (Fabricius), *Appias paulina* (Cramer), *Graphium eurypylus* (Linnaeus), *Euploea core* (Cramer), *Hypolimnas bolina* (Linnaeus), *Junonia villida* (Fabricius), *Cepora perimale* (Donovan), *Belenois java* (Linnaeus), *Catopsilia pyranthe* (Linnaeus), *C. gorgophone* (Boisduval), *Protographium leosthenes* (Doubleday), *Zizina labradus* (Godart), *Zizula hylax* (Fabricius)), representing four different families, were recorded moving southwards *en masse* in exceptionally large numbers during early January 2004 by lepidopterists in several localities. These localities included Pomona, 25 km SSE of Gympie, Qld (R.P. Mayo, pers. comm.), the Eudlo district, 80 km north of Brisbane, Qld (A.F. Atkins, pers. comm.) and Acacia Plateau in the Border Ranges (*c.* 700 m) between Killarney, Qld and Legume, NSW (A. Sundholm and R. Chin, pers. comms) (Fig. 1).

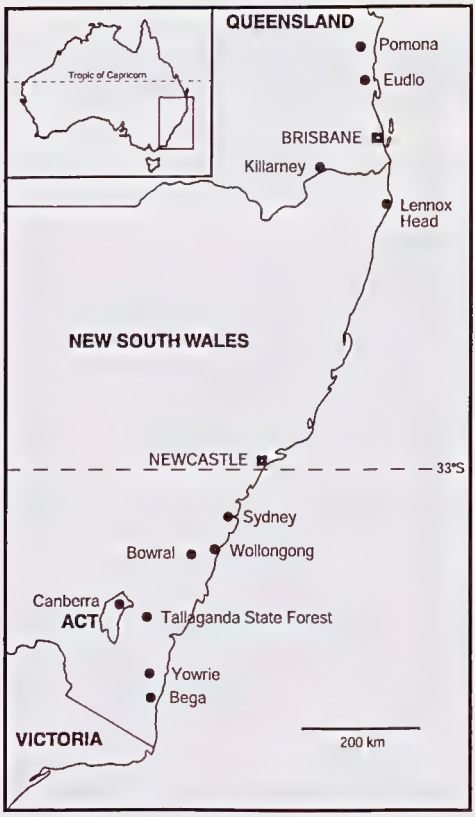


**Fig. 1.** Map of southeastern Australia, showing localities (•) referred to in the text where adults of *Appias paulina* and *Catopsilia pomona* were observed migrating south in SE Qld and NE NSW during January-February 2004 and where they were recorded in SE NSW and the ACT around the same period. Dashed line (latitude 33°S) near Newcastle, NSW, represents putative southern (temporary) breeding limit of the two species. The source of the migration was unknown but was probably in central coastal Queensland in the vicinity of the Tropic of Capricorn (23°S).

This migration, amongst the largest observed for many years in terms of both numbers of species and individuals, continued for several weeks well into February. Some of the more abundant species, such as *T. hamata* and *C. pomona*, were first noted in smaller numbers as early as late October or November 2003 and continued until about April 2004 (A.F. Atkins and R.P. Mayo, pers. comms). Other migratory species, such as *Badamia exclamationis* (Fabricius), *Eurema herla* (W.S. Macleay), *Junonia orithya* (Linnaeus) and *Hypolimnas misippus* (Linnaeus), which are more common in tropical latitudes and rarely seen in southeastern Queensland, also appeared around the same time in late summer 2004 (Mayo 2004 and pers. comm.).

Further south in New South Wales, several species, including *T. hamata, C. pomona, A. paulina, G. eurypylus, E. core, C. perimale* and *B. java*, were recorded migrating southwards at Lennox Head in northeastern New South Wales during January-February 2004 (C.G. Miller, pers. comm.). Around the same time, an influx of *T. hamata, C. pomona, A. paulina, H. bolina* and *Danaus chrysippus* (Linnaeus) was also noted in the Sydney district (Robinson 2004), an area where these species are not normally present. On the coast at Wollongong and on the southern tablelands near Bowral (640 m), NSW, Brown (2004 and pers. comm.) recorded the appearance of three species (*C. pomona, A. paulina, G. eurypylus*) throughout January and February 2004, as well as a single specimen of *P. leosthenes* (on 1 Feb. 2004) in a bushland garden at Bowral. The occurrence of *P. leosthenes* at Bowral was notable as this represented the first recording of the species in the district during the past 15 years of observation (S.S. Brown, pers. comm.).

Here I report on several observations of two pierid species, *A. paulina* and *C. pomona*, made opportunistically in the Australian Capital Territory (ACT) and southeastern New South Wales in January-February 2004, which may have been part of the same mass movement near the coast of southeastern Queensland and northeastern New South Wales. Small numbers of *D. chrysippus* were also recorded flying west, between mid February and mid March 2004, in the Belconnen area of the ACT and nearby areas but these observations are not detailed here. I use the term 'migration' in the sense of Dingle *et al.* (1999), in that the butterflies' behaviour consisted of persistent directional movement, undistracted by nectar sources (except for the acquisition of energy, usually during the morning), but not necessarily to the exclusion of oviposition on larval food plants.

**Observations**

*Appias paulina*

On 24 Jan. 2004, between 1530 and 1630 h (Daylight Saving Time), a mass directional flight was recorded by G. Guy, S. Caton, L.J. Aitchison and the author at Yowrie (36°19'S, 149°43'E; 200 m a.s.l.), about 15 km ENE of Cobargo, NSW. Butterflies were moving rapidly (approx. 4 m/sec or 14 km/hr) in a southerly direction over a 30-40 m front along a riparian corridor of tall open forest/woodland dominated by *Allocasuarina cunninghamiana* (Casuarinaceae) growing on the banks of the Yowrie River. Butterflies were counted moving across the front at a rate of one adult per minute during the one hour observation period (*i.e.* 60/hr). The migration was limited to the river valley, with adults flying within a few metres above the ground, either directly over the water surface or along the banks. They were not observed flying in the adjacent farmland. Most of the specimens of *A. paulina* collected at Yowrie were 'slightly worn' to 'worn' and none was 'fresh', as indicated by the extent of scale loss and damage to the wing margins. However, two specimens (Figs 2-5) were in good condition, with only slight

damage/loss to the margins and scales. Variation in wing condition suggests either a mixed age class or that individuals had travelled different distances.

Other observations of this species made by the author during the 2003-04 flight season in southeastern NSW and the ACT included: (1) 1 male observed flying south over the summit of a hilltop at Peak Alone, Wandella State Forest, NSW (36°18'S, 149°47'E; 960 m a.s.l.), 24 Jan. 2004, at about 1230 h (DST); (2) 3 males observed flying rapidly (approx. 6 m/sec or 22 km/hr) south in open parkland at Bega, NSW (36°40'S, 149°50'E; 50 m a.s.l.), 26 Jan. 2004, during periods of patchy sunshine between 1245 and 1415 h (DST); (3) 1 female in worn condition observed between the Botany and Zoology buildings, The Australian National University, Canberra, ACT (35°16'S, 149°06'E; 590 m a.s.l), 27 Jan. 2004, at 1530-1532 h (DST); the specimen appeared to be searching for flowers or possibly a perch on which to settle; (4) 1 female observed, 2 males collected (and released) whilst feeding at flowers in the Tallaganda State Forest (35°28'S, 149°34'E; 1100 m a.s.l.), approximately 15 km ESE of Hoskinstown, NSW, 1 Feb. 2004, during late morning and mid afternoon; (5) 2 females, 1 male observed at the same location as the previous record, but on 14 Feb. 2004.

*Catopsilia pomona*

On 1 Feb. 2004, at 1130 h (DST), an adult *C. pomona* was observed by J. Armstrong, C.E. Meyer and the author in eucalypt open forest on the Great Dividing Range in the Tallaganda State Forest (35°28'S, 149°36'E; 1250 m a.s.l.), approximately 16 km ESE of Hoskinstown, NSW. It appeared uniformly white above but slightly pinker below and was probably a male 'pale form', distinguished from males of *Appias paulina* (the only other similar species in both size and colour pattern in SE NSW and which was also present in the area), by the more rounded termen of the hindwing, lack of obvious black markings in the apex of the forewing and larger size.

Two days later, on 3 Feb. 2004 at 1315 h (DST), a male *C. pomona* 'dark from' was observed by the author flying rapidly (approx. 5 m/sec or 18 km/hr) in a westerly direction in degraded woodland/urban parkland, about 2.5 m above the ground, near the Macgregor Primary School (35°12'S, 149°00'E; 570 m a.s.l), Macgregor, 13 km NW of Canberra, ACT. The specimen was in view for approximately 10 sec before it disappeared behind residential houses. It flew in a constant direction and within a few metres of my position, allowing reasonable examination of its identity. Distinguishing features included: size (about the same size as male *Heteronympha merope* (Fabricius)), colour (fore and hind wings uniformly canary yellow) and pattern (faint black edging along wing margins). The only other yellow pierids in the ACT and adjacent areas of NSW, with which it could be confused, are *Eurema smilax* (Donovan) and *E. hecabe* (Linnaeus), the former of which regularly visits the region during migration. Both are substantially smaller in size and have a less powerful flight than *C. pomona*.


**Figs 2-5.** Examples of both sexes of *Appias paulina* collected from Yowrie, 15 km ENE of Cobargo, NSW, 24 Jan. 2004: (2) male upperside; (3) male underside; (4) female upperside; (5) female underside. Scale bar = 20 mm.

## Discussion

*Appias paulina* makes irregular and temporary extensions in range to southeastern NSW and eastern and central Victoria and, rarely, Tasmania, usually in summer (Smithers 1983); however, too few data are available to draw firm conclusions on overall patterns of movement throughout the species' range (Dingle *et al.* 1999). It is not listed for the ACT (Kitching *et al.* 1978), although in the rainforest gully of the Australian National Botanic Gardens both sexes, but especially males, were common for a brief period in late January 1998 (M.F. Braby, unpublished data). Two seasons earlier I recorded five adults flying west at Brown Mountain (1240 m a.s.l.) near Nimmitabel, NSW, on 26 Jan. 1996 between 1410 and 1450 h (DST) (1 male, 1 female collected). The southern distributional limit of *Drypetes deplanchei* (Euphorbiaceae), the primary larval food plant of *A. paulina*, lies in rainforest remnants in central coastal NSW (Hunter River valley near Newcastle) and this region is believed to be the southern breeding limit of the butterfly (Atkins 1992, Braby 2000). It is not certain, however, if *A. paulina* breeds

permanently or only temporarily (seasonally) in the Hunter River valley. Occurrences of *A. paulina* outside the breeding range south of Newcastle are believed to be the result of southward migration, but few details have been documented (Smithers 1983, Dingle *et al.* 1999). Appearances in the southern temperate areas are usually of short duration, although in some years the species may be relatively abundant (Smithers 1983, Atkins 1992).

Despite the fact that *Catopsilia pomona* has the common name 'Lemon Migrant', records of migration of this species are remarkably few (Dingle *et al.* 1999) and in far southeastern Australia the species appears to be a rare visitor (Common and Waterhouse 1981, Smithers 1983), especially in the more temperate areas south of about Sydney, where the species does not breed (Waterhouse 1932). In the 1991-92 summer season, when *C. pomona* and several other species of butterflies were recorded migrating south in central coastal NSW (Atkins 1992), it was collected at Wombarra, about 50 km SSW of Sydney, NSW (1 female 'pale form' collected 20 Feb. 1992 by F. Douglas, pers. comm.) and at Wamboin, about 7 km NW of Bungendore, NSW (1 male collected 7 Jan. 1992 by J. Armstrong, pers. comm.). It has not previously been recorded in the ACT (Kitching *et al.* 1978), but it has been sighted intermittently farther west in western and northwestern Victoria (Braby 2000) and once in South Australia, at Berri in 1935 (Fisher 1978). Most of these southern records occur in January and February when the species makes temporary extensions in range during migration, often coinciding with major southern invasions of *A. paulina* (Smithers 1983). The southern breeding limit has not been established with certainty, but Atkins (1992) noted that it breeds temporarily during the warmer months in central coastal NSW (Newcastle district). Permanent breeding populations are probably established much further north, possibly near the tropics.

The opportunistic observations made on *A. paulina* in southeastern NSW and the ACT during the 2003-04 flight season, together with those made on directional flights at Yowrie and Bega, suggest that a southern migration, resulting in temporary range extension of the species, occurred over at least a three week period between late January and mid February 2004. The two observations made on *C. pomona* in the same general area in early February 2004 coincided with this southern migration of *A. paulina*. More significantly, the observations made on these two species in the temperate areas of southeastern Australia coincided with the period when *A. paulina* and *C. pomona* were observed migrating in large numbers in southeastern Qld and northeastern NSW, as well as their sudden appearance in coastal areas and the southern tablelands of NSW during January and February 2004 (Fig. 1). Since the general movements throughout southeastern Australia were in a southern direction, particularly in *A. paulina*, it seems likely that the butterflies observed in southeastern NSW and the ACT were part of the same overall mass flight noted further north in January-February 2004.

Directional (southern) movements of *A. paulina* were recorded only in the coastal lowland areas of NSW, whereas the few specimens observed (of both species) in the ACT and nearby areas of Tallaganda State Forest (on the Great Dividing Range), NSW, were either flying west or not flying in any particular direction, particularly when feeding from flowers. On the southern tablelands at Bowral, NSW, the flight of *A. paulina* and *C. pomona* was also non-directional, with much time devoted to searching for and feeding from flowers (S.S. Brown, pers. comm.). This suggests that, in the higher latitudes south of Newcastle, part of the migration dispersed inland west of the Great Escarpment and Great Dividing Range. In this context it is notable that the individuals of *A. paulina* I observed eight seasons earlier, in late January 1996 in the uplands at Brown Mountain (40 km SW of Yowrie), NSW, a short distance inland of the Great Escarpment, were all flying west.

Bega, the southernmost record made for migrating *A. paulina*, is a coastal locality 35 km S of Yowrie, NSW and approximately 1200 km SSW of Pomona, Qld (the northernmost locality where migration was recorded). If the butterflies observed in coastal southeastern NSW at Bega and Yowrie were indeed part of the same general mass movement in southeastern Qld, then they must have travelled well over 1200 km. The source of the migration is not known but was probably further north, possibly in the dry rainforests of central coastal Qld near the vicinity of the Tropic of Capricorn (R.P. Mayo pers. comm.). If so, then some individuals may have travelled up to 1500 km, although it is possible that adults originating in northeastern NSW may have also joined the migration.

Taking an average of the two speeds estimated at Yowrie and Bega, a conservative estimate of the average velocity of *A. paulina* is 18 km/hr. If it is assumed that adults maintain this speed for at least half the day (*i.e.* for about six hours, with the remainder of the day devoted to resting, refuelling at nectar sources, puddling, etc)[1], then the average minimum distance travelled per day extrapolates to 108 km. At this speed, the distance between the Pomona district, Qld, and Yowrie-Bega, NSW, would be accomplished in a maximum of 11 days. The time difference may well be much shorter than this, particularly if butterflies vary their speed and/or temporal duration of flight, both of which may depend on environmental factors such as temperature and available sunshine. Nevertheless, a time lag of around 11 days between the two geographical areas would readily account for the appearance of *A. paulina* in southeastern NSW and the ACT during the same months when the species was also noted migrating by several observers in southeastern Qld and northeastern NSW.

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[1]In SE Qld during January 2004, R.P. Mayo (pers. comm.) estimated that *A. paulina* adults were migrating mainly from 1000-1500 h (EST), with reduced activity (puddling) during the heat of the day between 1200-1300 h.

The factors contributing to such movement patterns among Australian pierids have not been investigated, although climatic variables are suspected (Atkins 1992, Dingle *et al.* 1999). All observations in January-February were made during calm weather, so wind is not considered to be a likely factor. The mass migration in southeastern Queensland in early 2004 coincided with above average rainfall (1.7 fold increase) for January (279 mm compared with the monthly average of 159 mm for Brisbane) (Fig. 6b). Moreover, central coastal Qld (near the Tropic of Capricorn) experienced well above average rainfall (2.7 fold increase) three months earlier, in October 2003 (121 mm compared with the monthly average of 45 mm for Rockhampton), following a prolonged dry period (7 months) when the monthly rainfall was consistently below average (Fig. 6a). In contrast, rainfall for the same period was close to or, more frequently, below average for Brisbane and the wet season did not commence until December 2003 (Fig. 6b).

Many of the species noted migrating in southeastern Qld during January-February 2004 are associated with plants in disturbed areas or dry rainforest habitats and some are characterised by 'boom-bust' life cycles, in that populations build up rapidly only when conditions are seasonally favourable (see review chapters in Kitching *et al.* 1999). At least one species (*C. pomona*) breeds seasonally during the wet season and completes its life cycle rapidly, within 2-3 weeks (Rienks 1985, Jones *et al.* 1987). Assuming that the source of the migration was near the vicinity of Tropic of Capricorn, one scenario is that a significant rainfall event in October created conditions that triggered breeding and then migration several weeks later. The above average rainfall recorded in southeastern Qld three months later, in January 2004, may in turn have facilitated dispersal southwards and subsequent breeding within that region. Such an hypothesis is consistent with field observations, at least for *C. pomona* where adults were first noted migrating in southeastern Qld in late October-November 2003 and then were more abundant in January-February 2004 (A.F. Atkins and R.P. Mayo, pers. comms).

No return (northern) flights of *A. paulina* and *C. pomona* have been recorded in southeastern NSW, the ACT or eastern Victoria. Dingle *et al.* (1999) pointed out that, in species which are characterised by such unidirectional migrations into non-breeding areas, this will result in the loss of migrant genes from the population, raising interesting biological questions regarding the adaptive significance of such unidirectional (suicidal) flights. One theory, proposed by Dingle *et al.* (1999), is that such losses may be sustainable provided there is genetic variation in migrating capacity, such that a proportion of individuals (the short distance migrants) produce many offspring in suitable habitats before dispersing completely out of the breeding range (e.g. northeastern NSW in the case of the two pierid species). Adults from this next generation then gradually disperse back to the original source, but in substantially lower numbers.

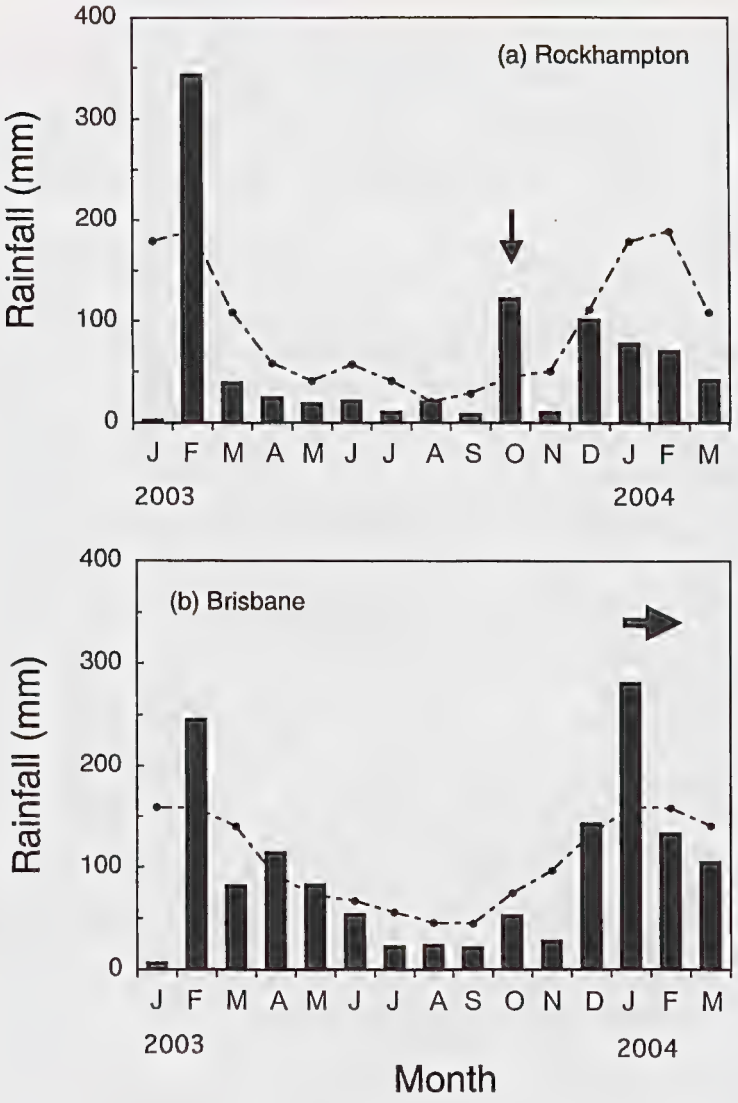


**Fig. 6.** Monthly rainfall data for the period January 2003-March 2004 for: (a) central coastal Queensland (Rockhampton) and (b) southeastern Queensland (Brisbane). Dashed line represents average monthly rainfall for each locality. Vertical arrow in (a) indicates start of the wet season with a significant rainfall event in October for Rockhampton following a 7 month dry spell. Horizontal arrow in (b) indicates major period when *Appias paulina*, *Catopsilia pomona* and many other butterflies were recorded migrating south *en masse* in SE Qld.

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## References

ATKINS, A.F. 1992. Migrating Lepidoptera in January, 1992, on the central coast of New South Wales. *Victorian Entomologist* **22**: 41.

BRABY, M.F. 2000. *Butterflies of Australia: their identification, biology and distribution*. 2 vols. CSIRO Publishing, Melbourne; xx + 976 pp.

BROWN, S.S. 2004. A range extension for *Protographium leosthenes leosthenes* (Doubleday) (Lepidopera: Papilionidae) in southern Australia. *Australian Entomologist* **31**(3): 110.

COMMON, I.F.B. and WATERHOUSE, D.F. 1981. *Butterflies of Australia*. Revised edition. Angus and Robertson, Sydney; xiv + 682 pp.

DINGLE, H., ZALUCKI, M.P. and ROCHESTER, W.A. 1999. Season-specific directional movement in migratory Australian butterflies. *Australian Journal of Entomology* **38**: 323-329.

FISHER, R.H. 1978. *Butterflies of South Australia*. Government Printer, Adelaide; 272 pp.

GREENSLADE, P.G., FARROW, R.A. and SMITH, J.M.B. 1999. Long distance migration of insects to a subantarctic island. *Journal of Biogeography* **26**: 1161-1167.

JONES, R.E. 1987. Reproductive strategies for the seasonal tropics. *Insect Science and Application* **8**: 515-521.

JONES, R.E., RIENKS, J., WILSON, L., LOKKERS, C. and CHURCHILL, T. 1987. Temperature, development and survival in monophagous and polyphagous tropical pierid butterflies. *Australian Journal of Zoology* **35**: 235-246.

KITCHING, R.L., EDWARDS, E.D., FERGUSON, D., FLETCHER, M.B. and WALKER, J.M. 1978. The butterflies of the Australian Capital Territory. *Journal of the Australian Entomological Society* **17**: 125-133.

KITCHING, R.L., SCHEERMEYER, E., JONES, R.E. and PIERCE, N.E. 1999. *The biology of Australian butterflies. Monographs on Australian Lepidoptera. Volume 6*. CSIRO Publishing, Melbourne; xvi + 395 pp.

MAYO, R.P. 2004. Interesting distribution records of butterflies in south east Queensland. *News Bulletin of the Entomological Society of Queensland* **32** (3): 64-65.

QUICK, W.N.B. 1974. Some abnormal insect records for the summers of 1972-3, 1973-4. *Victorian Entomologist* **4**: 66-71.

RIENKS, J.H. 1985. Phenotypic response to photoperiod and temperature in a tropical pierid butterfly. *Australian Journal of Zoology* **33**: 837-847.

ROBINSON, M. 2004. [No title]. *Butterfly and Other Invertebrates Club Newsletter* **32**: 20.

SMITHERS, C.N. 1983. Migration records in Australia. 4. Pieridae (Lepidoptera) other than *Anaphaeis java teutonia* (F.). *Australian Entomological Magazine* **10**: 47-54.

WATERHOUSE, G.A. 1932. *What butterfly is that?* Angus and Robertson, Sydney; 291 pp.